RDX IN GROUNDWATER AT DOD FACILITIES: AN OVERVIEW

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Introduction

The Department of Defense lead by the U.S. Army' cleanup program has spent a considerable amount of resources in the past decade and a half trying to understand the movement of explosive compounds in groundwater and the effects that these compounds on groundwater systems. Explosives have entered the groundwater environment from the manufacture and usage of many compounds in the explosive family. DoD facilities using explosives included manufacturing facilities, washout and maintenance facilities, as well as training ranges. It has been found that one explosive in particular RDX is both the most mobile and persistent in groundwater systems, but also appears to present at any facility that used explosives since its first usage during World War II. This presentation will discuss the types of disposal operations that have gone on through history and the present, the types of usage patterns which lead to environmental releases and the types of chemicals used in the both as feedstock for the manufacture of explosives compounds and the munitions themselves. Also to be discussed is an overview of our present state of knowledge of fate and transport of these compounds and an overview of some new cleanup technologies being developed to remove explosives from the environment.

Discussion

Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) is presently the most important military high explosive in use by the United States. The acronym is the British code name for Royal Demolition or Research Department Explosive. RDX has been is high use since its synthesis during the early parts of World War II. Ordinance of pure RDX is referred to as Composition A; blended with 40 percent TNT it is composition B. Due to its widespread usage, relative persistence and relative lack of attenuation in the groundwater environment, RDX is the most common explosive found in groundwater at levels that can pose risks to human health and the environment.

RDX has found its way into the groundwater environment from multiple sources including: (1) production facilities e.g. wastewater lagoons, filtration pits, disposal ditches and trenches; (2) demilitarization operations; e.g. lagoons, ditches, and trenches, (3) solid waste destruction facilities, e.g. burn pits, open burning/open detonation facilities, incineration wastes; and (4) dispersed sources, e.g. range operations. Each source and mode of RDX discharge to the environment, both past and present represent potentially unique suites of contaminant concentrations and initial conditions and therefore leading to dramatic differences in potential RDX fate and transformation in the groundwater environment. In general, the former practices of wastewater disposal from manufacturing and demilitarization operations pose the greatest threats to groundwater. RDX from these operations were introduced to the environment as concentrated aqueous solutions into lagoons and drainage ditches. While these practices have not gone on since the late 1970's or early 1980's the effect of these operations are just now being fully felt. While these solutions sometimes had time on the surface to be reduced by phototransformative reactions for the most part these solutions percolated directly into the subsurface. Concentrations in groundwater in these sources areas from these types of operations have been seen up to 100 of parts per million. These manufacturing and demilitarization operations not only produced aqueous solutions with high RDX concentrations but also create groundwater mounds due to the disposal of millions of gallons of wastewater per day which speed up the RDX dispersal through the subsurface.

Recently much attention has been focused on the potential that range operations could be contributing RDX contamination to the groundwater. These sources include leakage from unexploded ordnances, partially exploded ordnances, and residues from the combustion of explosives. Much lower concentrations of RDX in groundwater has been found so far at ranges in 1 –10 parts per billion range but still potentially at concentrations that could pose a risk to human health and the environment.

Advection, dispersion, diffusion, abiotic reactions, and biotransformation are the most significant processes affecting the transport of RDX in the groundwater environment. While the use of Darcy equation flow is adequate to describe the advection and dispersion of RDX in groundwater the rest of the major processes are not so simple. RDX is a weakly binding organic compound may be adequately described with a simple linear sorption isotherm, many of its breakdown products are highly susceptible to irreversible sorption but covalent binding to soil components. This factor has often lead to great difficulties in the analyses of the breakdown of RDX in groundwater as RDX seem to be decreasing in groundwater but there is no similar increase in breakdown products. In situ biodegration mainly involves the reduction of the nitro groups to amino groups in the presence of a primary substrate. While this process takes place a slow rate naturally it is hoped that additional in situ remediation technologies will be perfected utilizing biodegradation and will become the prime remedial technology for groundwater.

Several new remedial technologies have been developed in the past decade. These technologies include ex-situ technologies of phytoremediation, optimized granulated activated carbon usage, UV/Ox and hot gas decontamination techniques. Also several new in-situ technologies have been developed and used including chemical oxidation (Fenton's reagent and permanganate), enhanced biodegradation (HRC, molasses, edible oil), reactive walls and monitored natural attenuation. Examples of these technologies usage at sites will be discussed as well as an example of monitored natural attenuation will be shown.

References

Brannon, J. 1997, Review of Fate and Transport Processes of Explosives, WES Technical Report IRRP-97-2, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS

Cataldo, D.A., S.D. Harvey, R.J. Fellows et al. 1989, An Evaluation of the Environmental Fate and Behavior of Munitions Materiel in Soil and Plant Systems, Environmental Fate and Behavior of TNT, Project Order 88PP8853, US Army Medical Research and Development Command, Fort Detrick MD

Cataldo, D.A., S.D. Harvey, R.J. Fellows, 1990, , An Evaluation of the Environmental Fate and Behavior of Munitions Materiel in Soil and Plant Systems, Environmental Fate and Behavior of RDX, Project Order 88PP8853, US Army Medical Research and Development Command, Fort Detrick MD

McGrath, C, 1995, Review of Formulations for Processes Affecting the Subsurface Transport of Explosives, WES Technical Report IRRP-95-2, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS

Leggettt, D.C. 1985 Sorption of Military Explosive Contaminants on Bentonite Drilling Muds, CRREL Report 85-15, US Army Corps of Engineers Cold Regions Research and Engineering Laboratory, Hanover, NH

Meyers, T.E., J.M. Brannon, J.C. Pennington, et al. 1998, Laboratory Studies of Soil Sorption/Transformation of TNT, RDX, and HMX, WES technical Report IRRP 98-8, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS

Pennington, J.C. 1988, Plant Uptake of 2,4,6 – Trinitrotoluene, 4-amino-2,6- Dinitrotoluene, and 2-amino-4,6,-Dinitrotoluene using 11Cl labeled and Unlabeled Compounds, WES Technical Report EL-88-20, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS

Townsend, D.M. and T.E. Meyers, 1996, Recent Developments in Formulating Model Descriptors for Subsurface transformation and Sorption of TNT, RDX and HMX, WES Technical Report IRRP-96-1 US Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS